

VIC DATA INPUTS AND OPTIONAL PROCESSES

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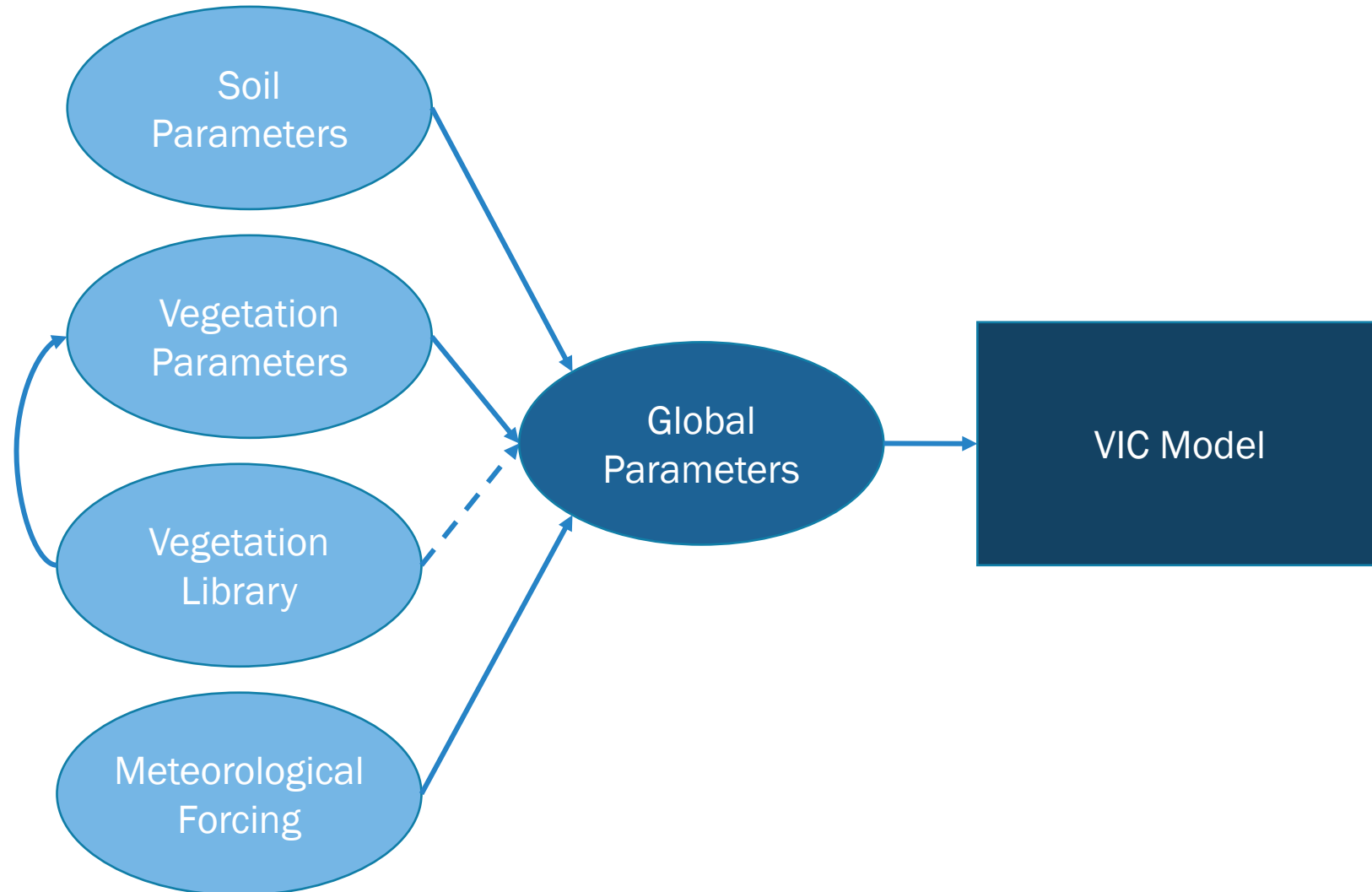
University of Alabama in Huntsville | Earth System Science Center

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VIC/BCSPP Training
Huntsville, AL



- The VIC model is complex requiring large amount of data in stored in multiple files
- Much of the data can be acquired from remote sensing/GIS data sets



- Main input file for VIC
- Sets some model parameters and options
- Points VIC to the locations of other input/output file
- Sets parameters that govern the simulation
 - Start/end dates
 - Model modes
 - Physical processes

```
#####
# VIC Model Parameters - 4.2.x
#####
# $Id$
#####
# Simulation Parameters
#####
NLAYER 3    # number of soil layers
NODES    10  # number of soil thermal nodes
TIME_STEP 24 # model time step in hours (set to 24 if FULL_ENERGY = F)
SNOW_STEP 24 # time step in hours for which to solve the snow model (s
STARTYEAR 1980 year model simulation starts
STARTMONTH 01 # month model simulation starts
STARTDAY 01 # day model simulation starts
STARTHOUR 00 # hour model simulation starts
ENDYEAR 2010 year model simulation ends
ENDMONTH 12 # month model simulation ends
ENDDAY 31 # day model simulation ends

#####
# Energy Balance Parameters
#####
FULL_ENERGY FALSE # TRUE = calculate full energy balance; FALSE = c
CLOSE_ENERGY FALSE # TRUE = all energy balance calculations (canopy
# and ground surface) are iterated to minimize th
```

- Global parameter file documentation:
<http://vic.readthedocs.io/en/master/Documentation/Drivers/Classic/GlobalParam/>

- Defines the spatial representation of the model
 - Grid cell ID
 - Latitude/longitude
- Model links the rest of data inputs through soil file by using grid cell ID
- Defines soil parameters at surface and each depth
- Defines initial soil moisture conditions when no state file is used

Run value

Grid cell ID

Lat/Lon

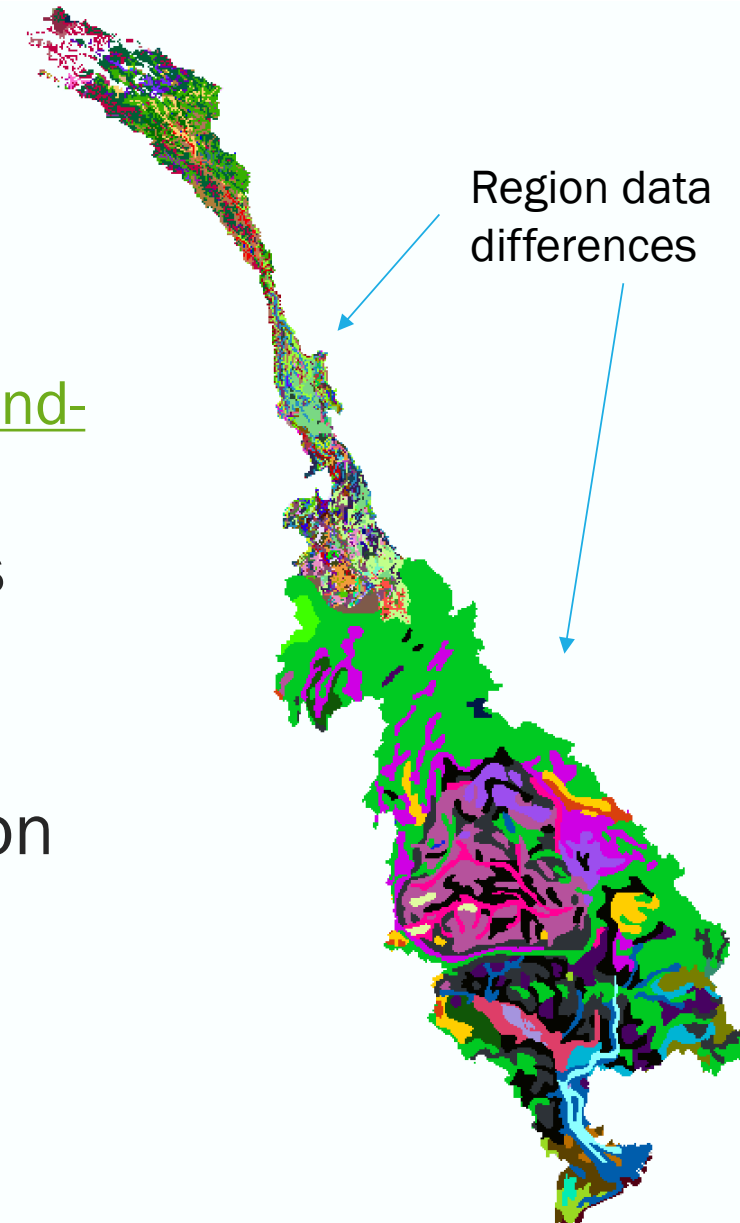
Soil parameters

1	4373	15.6058	107.0932	0.125	0.325	94.0823	0.96	2	13.6	13.6	13.6
1	4374	15.6058	107.3454	0.125	0.325	60.8905	0.96	2	13.6	13.6	13.6
1	4411	15.3546	101.5466	0.1	0.3	8.8226	0.95	2	20.32	19.04	576.0
1	4412	15.3546	101.7987	0.15	0.35	2.9614	0.975	2	13.6	19.04	19.04
1	4413	15.3546	102.0509	0.1	0.3	3.4251	0.95	2	20.32	19.04	576.0
1	4414	15.3546	102.3030	0.1	0.3	2.7713	0.95	2	20.32	19.04	576.0
1	4415	15.3546	102.5551	0.15	0.35	2.0940	0.975	2	13.6	19.04	19.04
1	4416	15.3546	102.8072	0.15	0.35	1.8068	0.975	2	13.6	19.04	19.04
1	4417	15.3546	103.0593	0.15	0.35	1.7430	0.975	2	13.6	19.04	19.04
1	4418	15.3546	103.3115	0.15	0.35	1.2203	0.975	2	13.6	19.04	19.04
1	4419	15.3546	103.5636	0.15	0.35	0.9377	0.975	2	13.6	19.04	19.04
1	4420	15.3546	103.8157	0.15	0.35	1.0616	0.975	2	13.6	19.04	19.04
1	4421	15.3546	104.0678	0.15	0.35	1.2873	0.975	2	13.6	19.04	19.04

- Soil parameter file documentation:

<http://vic.readthedocs.io/en/master/Documentation/Drivers/Classic/SoilParam/>

- Soil information is poorly known
- Harmonized World Soil Database (HWSD)
 - 30 arc-second (~1km) raster database
 - Classified raster grid with database look-up information
 - <http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/>
- Contains over 15,000 different soil mapping units
 - Has multiple soil parameters per mapping unit
 - **Used for soil pedotransfer functions**
- Accuracy and mapping information differs by region
 - Example: Lower vs Upper Mekong



- Defines land cover types present and fractional areas for a grid cell
- Also define rooting depths and rooting distributions for each land cover type
- Optional parameter setting:
 - Blowing snow
 - LAI
 - Vegetation cover
 - Albedo

2	1								
10	1.0000	0.1	0.1	1.0	0.65	0.5	0.25		
3	1								
10	1.0000	0.1	0.1	1.0	0.65	0.5	0.25		
4	3								
10	0.9759	0.1	0.1	1.0	0.65	0.5	0.25		
15	0.0238	0.1	0.1	0.5	0.8	0.25	0.1		
16	0.0003	0.1	0.1	0.75	0.8	0.25	0.1		

Grid cell ID

Number of vegetation classes

Vegetation class

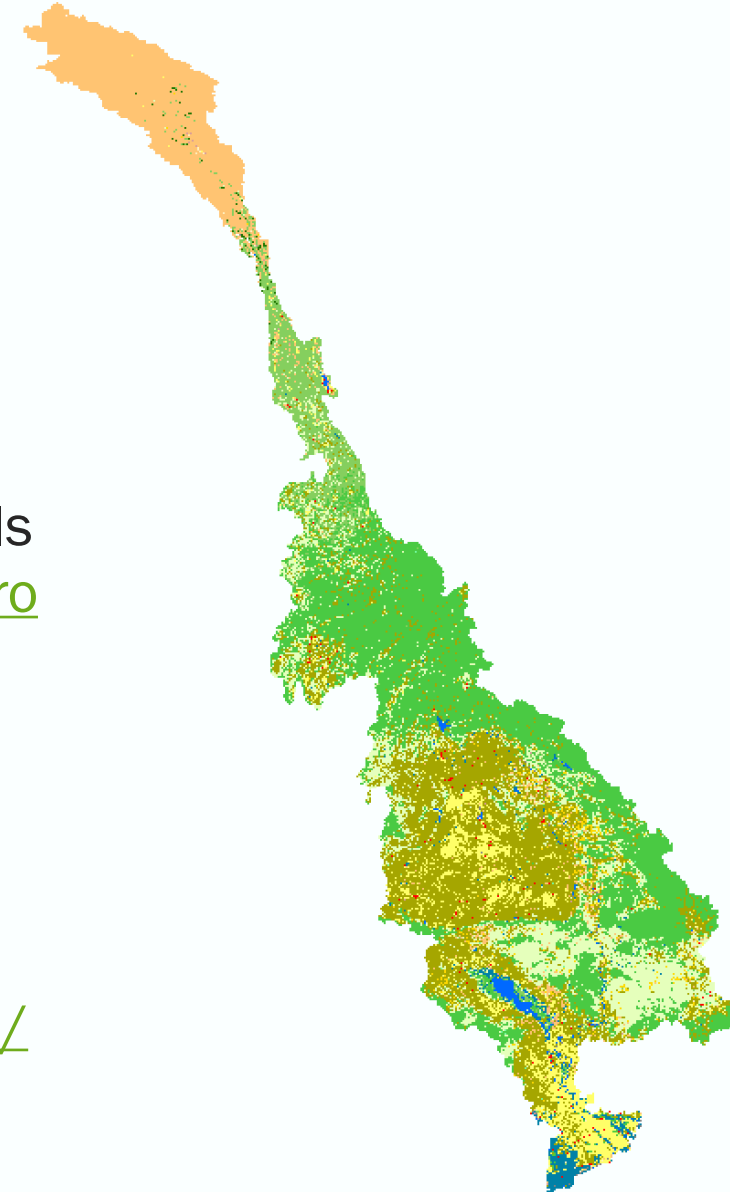
Fractional cover

Rooting depths

Root distribution

- Vegetation parameter file documentation:
<http://vic.readthedocs.io/en/master/Documentation/Drivers/Classic/VegParam/>

- Can **use whichever** land cover dataset/classification **best fits your needs**
 - Create vegetation parameter file
 - Extract information for vegetation library
- MODIS Combined Land Cover Product (MCD12Q1) IGBP classification
 - Fairly accurate mapping at global scale
 - Existing land cover parameterizations for land surface models
 - https://lpdaac.usgs.gov/dataset_discovery/modis/modis_products_table/mcd12q1
- Create your own land surface parameterization scheme or use existing
 - NCAR NOAH LSM parameterizations
 - <http://www.ral.ucar.edu/research/land/technology/noahmp/HRLDAS-v3.6/VEGPARM.TBL>



- Defines land parameterization for model
 - Parameterization provided for each possible land cover class
 - Library file referenced by vegetation parameter file

- Vegetation library file documentation:
<http://vic.readthedocs.io/en/master/Documentation/Drivers/Classic/VegLib/>

- Use observed remote sensing datasets to create your own land surface parameterizations
 - Need monthly climatology information for albedo and LAI parameters
- MODIS LAI and albedo products (2000-present)
 - LAI: https://lpdaac.usgs.gov/dataset_discovery/modis/modis_products_table/mod15a2
 - Albedo: <http://modis-atmos.gsfc.nasa.gov/ALBEDO/index.html>
- Can use remote sensing datasets for vegetation height, surface roughness, etc.
 - Large errors with derived data
 - Can lead to errors in model
- *Should you use observed remote sensing data or existing parameterization?*



- Not a required input
- Used to partition grid cell into different elevation for more accurate orographic effects
- Set maximum number of elevation band
 - Each grid needs the maximum number of bands specified (fill non-existent bands with zeros)

7	0.7139	0.2561	0.0263	0.0037	0.0000	0.0000	0.0000	0.0000	0.0000	1256.9296	1335.9584	1427.7449	1531.3063	0.0000	0.
8	0.1918	0.5602	0.1446	0.0907	0.0126	0.0000	0.0000	0.0000	0.0000	1282.4463	1342.8496	1446.6097	1539.5243	1629.3716	
9	0.3913	0.4651	0.1265	0.0171	0.0000	0.0000	0.0000	0.0000	0.0000	1377.0970	1437.1366	1540.3333	1633.3934	1703.0000	
10	0.2079	0.3771	0.2244	0.1097	0.0519	0.0185	0.0101	0.0003	0.0000						
11	0.0022	0.0744	0.1235	0.1223	0.2079	0.3223	0.1405	0.0069	0.0000						
13	0.1778	0.2938	0.3229	0.1657	0.0399	0.0000	0.0000	0.0000	0.0000						
14	0.0369	0.1398	0.7016	0.1212	0.0005	0.0000	0.0000	0.0000	0.0000						
15	0.0002	0.2228	0.3332	0.3470	0.0968	0.0000	0.0000	0.0000	0.0000						
16	0.0413	0.6030	0.2201	0.1247	0.0108	0.0000	0.0000	0.0000	0.0000						
17	0.0338	0.4448	0.4322	0.0891	0.0000	0.0000	0.0000	0.0000	0.0000						

Grid cell ID

Band percent coverage

Average band elevation

- Elevation band file documentation:
<http://vic.readthedocs.io/en/master/Documentation/Drivers/Classic/SnowBand/>

- Plethora of DEM datasets available
 - SRTM, GMTED, HydroSheds, NED, etc.
 - <http://www2.jpl.nasa.gov/srtm/>
 - <https://lta.cr.usgs.gov/GMTED2010>
 - <http://www.hydrosheds.org/>
 - <https://lta.cr.usgs.gov/NED>
- SRTM has relatively high accuracy, but also relatively high spatial resolution compared to model resolution
 - **Trade-offs between resolution and accuracy**
- Elevation data used to:
 - Create snow bands file
 - Prepare routing model inputs
 - Parameterize soils inputs



- VIC requires **four meteorological variable inputs** as a **time series** for **each grid cell**:

- Daily maximum temperature ($^{\circ}\text{C}$)
- Daily minimum temperature ($^{\circ}\text{C}$)
- Surface wind speed (m/s)
- Precipitation (mm)

- Other meteorological inputs are supported:

- Sub-daily temperature ($^{\circ}\text{C}$)
- Surface albedo (fraction)
- Atmospheric density (kg/m^3)
- Downward short and longwave radiation (W/m^2)
- etc.

- Sub-daily meteorological data is needed for energy balance equations!

0.0	25.8736387773	11.6867490022	1.69229154099
0.0	25.0211709978	11.7448292859	1.16774201477
0.0	25.611851829	12.0262697464	0.324097325307
0.0	26.096629529	15.1403686149	1.22808124204
0.0	26.3961641281	15.3278849594	0.963624083056
13.0455226898	24.4259464679	16.2561738367	0.511451343088
0.0	25.0257146965	14.4228281957	2.39866250826
0.0	26.2014841144	14.2582120773	2.70641091477
0.0	26.5758149844	13.2356671968	2.42862107304
0.0	25.6733665192	16.8227055183	0.940178950941
0.0	26.7739901509	16.3202280924	1.63142385214
0.0	27.3325155759	16.2538506253	2.20136782584
1.26945543289	24.8044715213	15.8502756254	0.678654029546
0.0	25.6887451917	15.1908154899	0.749539317564
0.0	26.3993097656	15.4241322867	1.94970258643

- Meteorological forcing data is used to **drive the model processes**
- **High degree of accuracy is needed** for these datasets, otherwise model will not capture correct conditions
- Meteorological forcing input data needs to be mapped to model grid cells
 - Need to interpolate station data
- Global datasets
 - Temperature
 - ERA-Interim, <http://www.ecmwf.int/en/research/climate-reanalysis/era-interim>
 - MERRA-2, <https://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/>
 - CSFR, <https://www.ncdc.noaa.gov/data-access/model-data/model-datasets/climate-forecast-system-version2-cfsv2#CFS>
 - Princeton dataset, <http://hydrology.princeton.edu/data.pgf.php>
 - Reanalysis
 - Precipitation
 - Next slide...

- Global datasets (continued)
 - Precipitation:
 - CHIRPS, <http://chg.geog.ucsb.edu/data/chirps/>
 - IMERG, https://disc.gsfc.nasa.gov/datareleases/imerg_data_release
 - CMORPH, http://www.cpc.ncep.noaa.gov/products/janowiak/cmorph_description.html
 - GPCC, <https://www.esrl.noaa.gov/psd/data/gridded/data.gpcc.html>
 - Reanalysis
 - Wind: Reanalysis
 - Station data:
 - GSOD, <https://data.noaa.gov/dataset/global-surface-summary-of-the-day-gsod>
 - GHCN, <https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/global-historical-climatology-network-ghcn>
- Typically lack spatial resolution but have required variables and temporal resolution

- VIC supports a wide variety of modeling applications
 - **Open source nature** of model development
 - You can contribute!
- Can specify which model modes/components you would like to use for your own applications
 - For example: Water balance mode vs full energy balance mode
 - Most often needs additional data inputs

Example: http://hydro.washington.edu/forecast/monitor_west/

- Distributes precipitation throughout grid cell as a **function of rain intensity**
 - Can account for orographic effects with small scale precipitation
 - Parameterize using climatology
- Fractional coverage is based on exponential relationship
- Soil moisture is averaged for grid cell before a new storm occurs
- Spatially distributing rain is parameterized within the snow bands file

- Important component in **cold regions** (high elevations or high latitudes)
- Frozen soils can **impede the infiltration of water** content
- Can alter spring soil moisture content and timing of streamflow
- Has impact of the energy balance
 - Energy balance is solved at each node within the soil and iterated for convergence

VIC Frozen Soil Algorithm

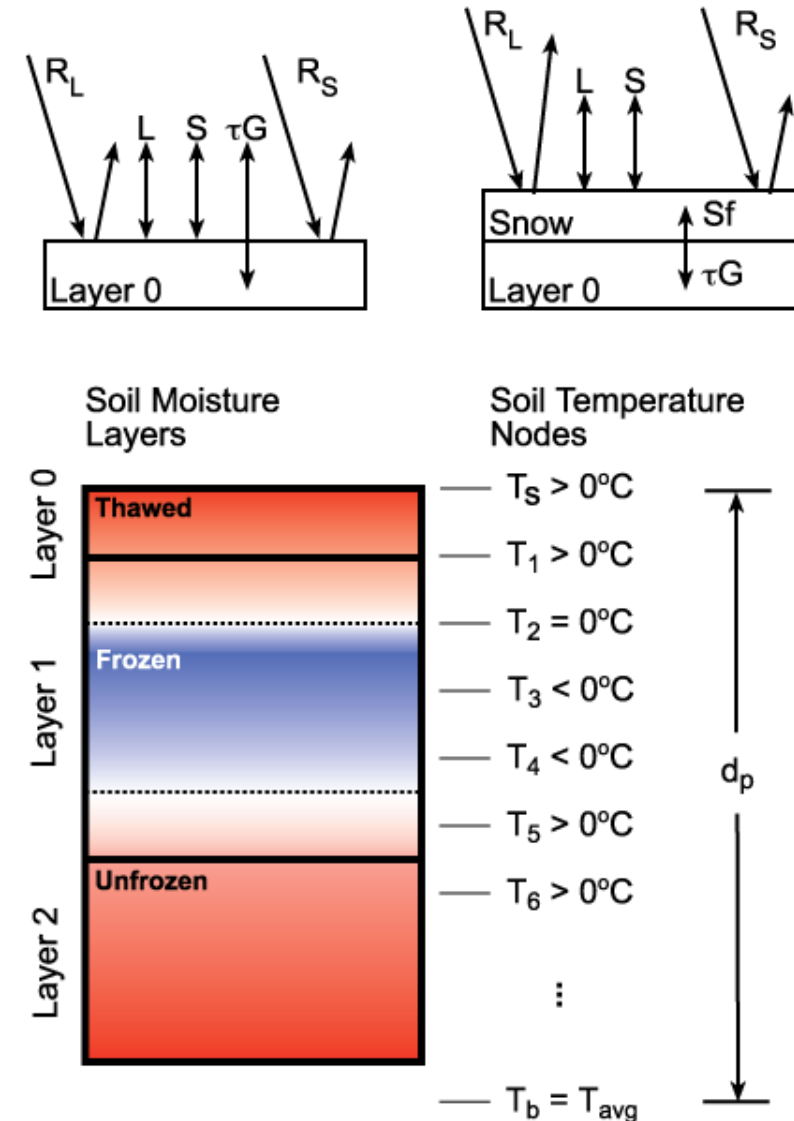


Image from Open Access VIC Documentation:
<http://vic.readthedocs.io/en/master/Overview/ModelOverview/>

- Solves lake energy balance at different layers
 - Incorporates lake ice coverage, **more realistic representation of surface processed over lakes**
 - Takes into account water in/outflow
 - Assumes "one" lake per grid cell
- Wetland model allows for season inundation of wetlands
 - Better models the **inter-annual water balance for wetland areas**
 - Channel/soil recharge depending on flux demand

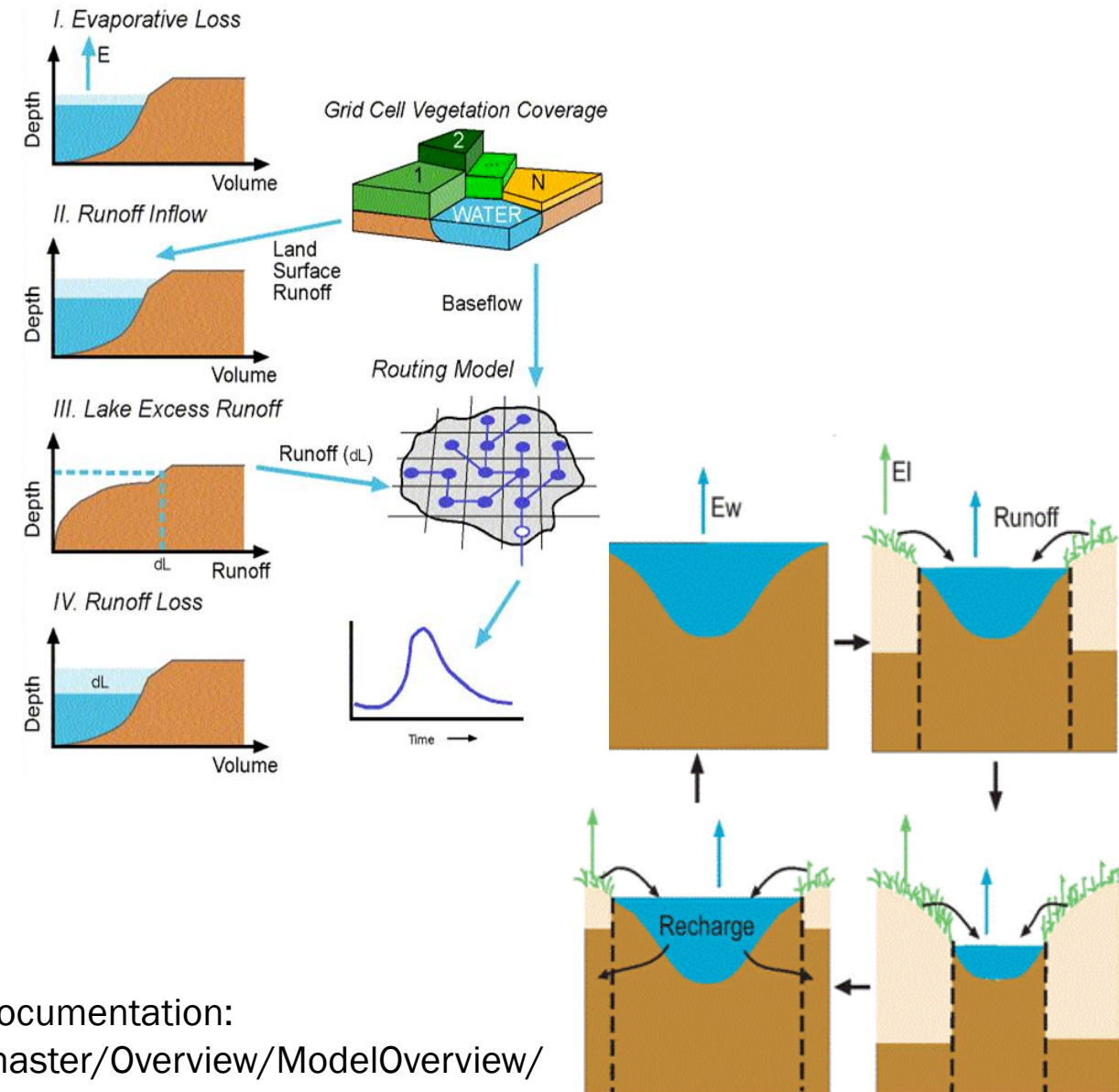
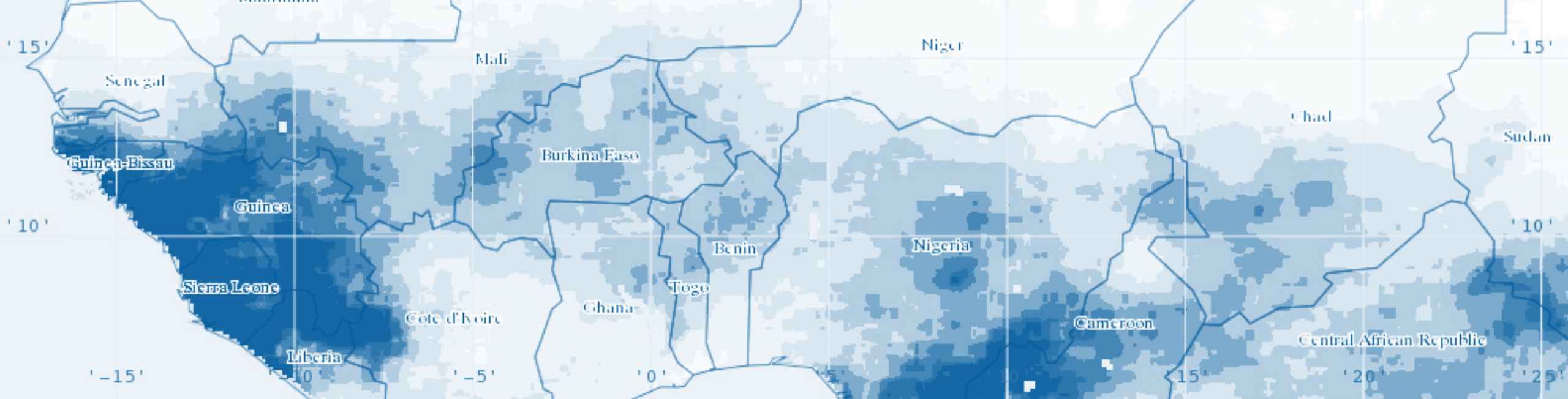


Image from Open Access VIC Documentation:
<http://vic.readthedocs.io/en/master/Overview/ModelOverview/>

- Allows for the simulation of vegetation photosynthesis and respiration
- Plant phenology is **not dynamic**
 - Based on land surface parameterization (monthly LAI climatology)
- Vegetative biomass is not simulated
 - Total carbon storage in plants
- Calculates yearly **Net Primary Productivity (NPP)** based on vegetation type and meteorological conditions

- Users can save last model conditions (specifically soil moisture conditions) to file
- Important if using the model for hydrologic forecasts
 - Minimum model spin-up time is 1 year
- Saves computation time
- Model outputs are not consistent when using state files
 - Small differences in soil moisture results between using and not using a state file



THANK YOU

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